Smart Buoys Help Protect Submarine Base

HOMELAND security experts are evaluating a wide range of possible threats from terrorists. One of the more troubling scenarios is a small and crude nuclear device transported in and detonated from a boat located near a naval military base or a civilian shipping terminal. Thanks to a Livermore design, buoys outfitted with commercially available radiation detectors could soon play an important role by warning of the presence of nuclear materials in marine environments.

Two such buoys guard the marine entrance to the U.S. Navy's submarine base at Kings Bay, Georgia. Housing radiation detectors, telemetry systems, and solar- and wind-powered generators, the buoys are proving themselves in a demonstration project sponsored by the Defense Threat Reduction Agency (DTRA).

New Security Uses for Existing Technology

DTRA, a federal agency charged with safeguarding the nation from weapons of mass destruction, has formed a partnership with the National Nuclear Security Administration (NNSA) to evaluate commercially available technologies that could be deployed quickly to defend against threats posed by weapons of mass destruction. One of the agencies' top priorities is preventing nuclear weapons, including crude devices and so-called dirty bombs, from being delivered by unconventional means, such as by car or boat.

Livermore nuclear engineer John Valentine says that the goal is to improve the Department of Defense's ability to detect, identify, respond to, and prevent unconventional nuclear attacks. "We want to determine how we can protect military bases by using commercial technology to detect nuclear materials that might be delivered by truck or boat." He says that if the new detection devices are successful, they could also be installed in civilian areas such as busy ports.

Valentine, who led the engineering tasks for the buoy demonstration project, notes that Livermore experts have also taken part in nuclear detection system demonstrations at Kirtland Air Force Base in New Mexico, Camp Lejeune Marine Base in North Carolina, and Fort Leonard Wood Army Base in Missouri.

At Kings Bay, Georgia, two buoys containing radiation detectors guard the marine entrance as part of a demonstration project sponsored by the Defense Threat Reduction Agency.

All three projects involved demonstrating radiological "sentries" for monitoring large areas of land. The sentries, including stationary radiological sensors placed along roads and units mounted inside vehicles, were designed to identify and track any vehicle that posed a threat.

Located about 48 kilometers north of Jacksonville, Florida, Kings Bay is surrounded by islands, and the area has heavy recreational traffic. For the demonstration, the national laboratories were asked to use equipment capable of operating in marine environments and detecting nuclear materials that might be used by terrorists, demonstrate their reliability and performance, and incorporate them with a base's existing security system. The Livermore buoys are one of three water-based detector platforms under evaluation at Kings Bay. Two other designs, by Sandia and Los Alamos national laboratories, are floating platforms.

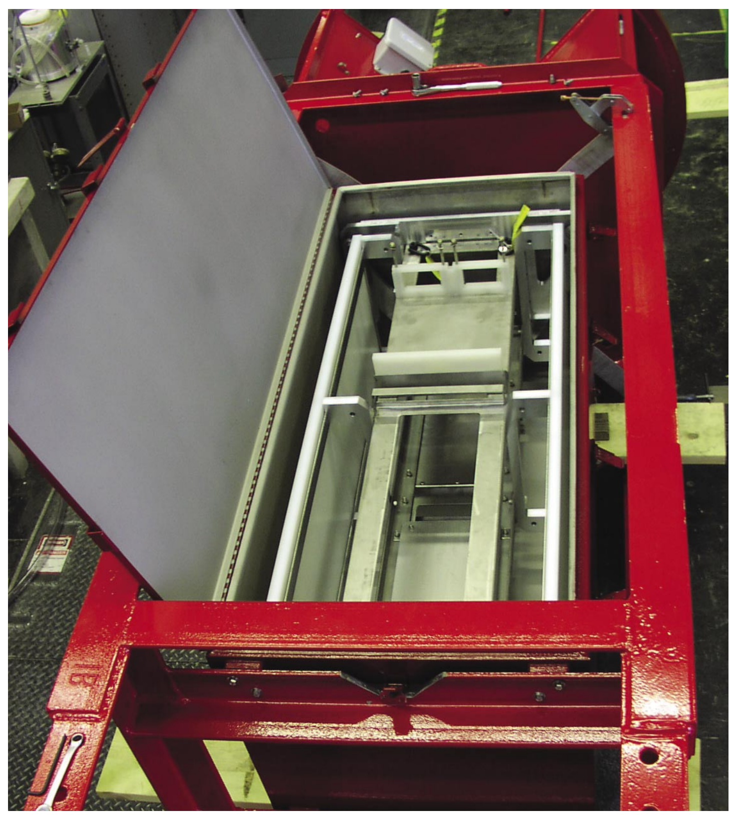
Valentine says that buoys offer several advantages for marine environments. They are built to withstand the rigors of salt water and high winds, they are unremarkable, and they can be situated in any body of water that is at least 10 meters deep. However, buoys also offer challenges such as furnishing adequate power to the detectors and other instruments, transmitting data to the base, and calibrating their detectors when the background radiation levels are not well known.

Buoy Design and Fabrication

The Kings Bay project involved Livermore people from the Engineering; Nonproliferation, Arms Control and International Security (NAI); Chemistry and Materials Science; and Computation directorates. The biggest challenge for the team, led by NAI's Jim Morgan, was to get from design to deployment in just four months. Designs for the two buoys (consisting of a base and tower) were finalized in October 2002. Two commercial stainless-steel buoys, one painted red and the other green, were manufactured in Houston and delivered by truck to Lawrence Livermore on Thanksgiving weekend for modifications. The buoys weigh 6,800 kilograms each and measure 2.4 meters in diameter by about 8 meters tall. About half of the base floats under water.

The team designed and then had constructed a pair of leakproof, stainless-steel enclosures for insertion inside each buoy tower. Within each enclosure is a shock-mounted internal frame on which several kinds of neutron and gamma-ray detectors are mounted so that the team can compare their effectiveness. "Although we are using some recently developed detectors, some of the detector technology in the buoys is about 50 years old," says Valentine. "Thus, in many respects, this project is best described as a novel implementation of existing technology. No one, to our knowledge, had ever put radiation detectors on buoys before."

Two commercial stainless-steel buoys, one painted red and the other green, were manufactured in Houston and delivered to Lawrence Livermore on Thanksgiving weekend 2002 for modifications. The buoy towers, which were attached in Kings Bay, are visible just behind the cab.



The team installed a stainless-steel enclosure inside each buoy tower for holding several kinds of radiation detectors and other sensors.

Sensors monitor the pitch, yaw, and roll of the buoy. Monitoring the buoy's orientation in three dimensions is important to recognizing a threat from the right craft. Other instruments record internal frame temperature (detectors are affected by heat), salinity of the water, and the status of an array of 12-volt photovoltaic batteries. The 16 batteries are powered by four, 55-watt solar panels and a small wind turbine.

Each buoy has a radio for transmitting data back to a receiver on base, where the data are carried by optical fiber to security headquarters. In addition, two video cameras are trained on the buoys from a pier about a kilometer away.

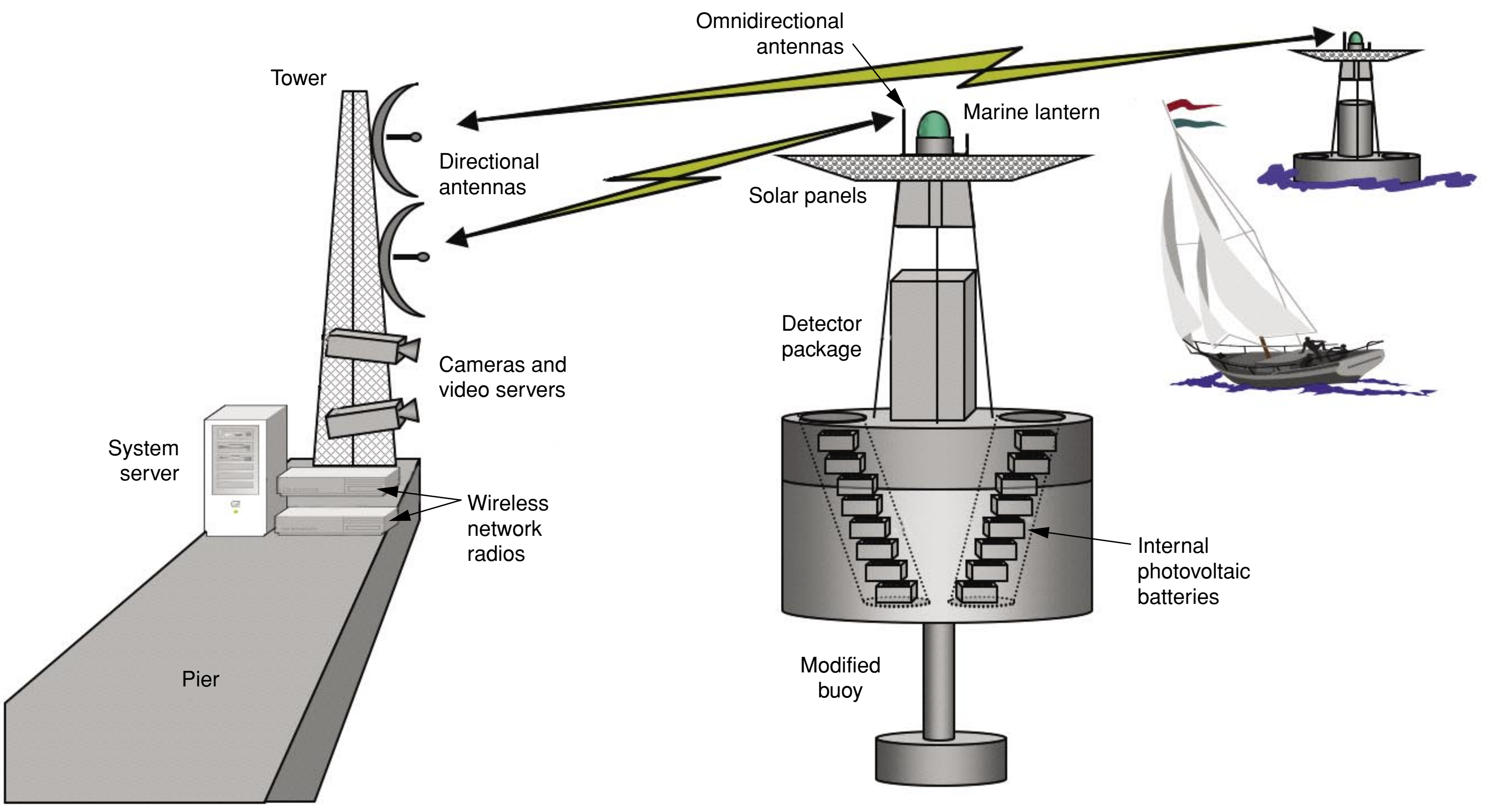
The buoys and their associated equipment arrived at Kings Bay on December 27, 2002. The two enclosures with all the equipment were mounted inside the towers early in January, and then the towers were mounted on the buoy bases. Following final assembly and testing, the buoys were attached to their anchors (5,600-kilogram chunks of concrete) and deployed on January 7, 2003, from a barge-mounted crane. The green buoy is in 15-meter-deep water, and the red buoy is in 10 meters of water. They are separated by 274 meters.

Putting the Buoys to the Test

The buoys are located about 2,200 meters outside a gate that opens and closes to let submarines in and out of the Kings Bay base. The Livermore team was required to obtain approvals from the Navy and Coast Guard for the exact location to place the buoys, which were officially numbered and entered on nautical charts.

"The buoys are serving as a test bed that allows us to evaluate the capabilities of the different detectors," says Valentine. The team is also tracking the performance of the onboard computer, telemetry, power systems, and sensors.

On January 16, 2003, a demonstration of all the prototype marine detector platforms was held before about 80 guests, including representatives from Congress, the Department of Defense, NNSA, DTRA, the Department of Homeland Security, and the Department of Justice. A pontoon boat carrying a variety of radionuclides passed by the detector platforms. In response, both buoys sent messages to base security that the background radiation limit had been exceeded. Valentine says that a guard in the base security building could see two icons (representing the two buoys) on a computer



Inside each buoy is a set of 16 photovoltaic batteries charged by four solar panels and a wind turbine.
On shore, two directional antennas receive data from the buoys, and two video cameras are trained on them.

console turning from green to flashing red. Catherine Montie, DTRA program manager, gave the demonstration an “A+,” and Valentine anticipates that the buoys will remain deployed while funding continues.

“The demonstration was an important first step,” says Valentine. He is leading a follow-on effort that involves upgrading the computer software and hardware, establishing a temporary remote (from Livermore) monitoring capability, characterizing the marine background radiation around Kings Bay, and determining better the capabilities of the different detectors.

“We know a lot about terrestrial background radiation but much less about radiation levels on the water. We know that radiation levels can vary considerably during the day and night on land. That may also be true at sea. At Kings Bay, the water is brackish. During high tide, it is mostly salt water, and during low tide, it is mostly fresh water. The differences in salinity may cause changes in background radiation.”

Valentine says the buoys could be integrated into the base security system in the near future. Then when a threat appears, a security guard will be able to click on a red flashing computer icon, see a real-time video image of the area around the buoy, and learn of the probable radioisotopes carried by the suspicious vessel.

Valentine also says that similar buoys could be put to good use in busy harbors. Proposals have already been submitted to deploy buoys with radiation detectors in the harbor at Oakland, California. Buoys, a common marine sight, may prove to be the next level of protection in the war on terrorism.

—Arnie Heller

Following final assembly and testing, the buoys were deployed January 7, 2003, from a barge-mounted crane.

Key Words: Defense Threat Reduction Agency (DTRA); homeland security; radiation detector; U.S. Navy submarine base at Kings Bay, Georgia.

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